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The alien Black-and-yellow Mud Dauber, *Sceliphron caementarium* (Drury, 1773) (Hymenoptera, Sphecidae), continues its spread: new citizen-science records from Eastern Europe and the Balkans

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Abstract

The Nearctic *Sceliphron caementarium* (Drury, 1773) is widely distributed in the Western Palearctic and is spreading to new territories. Despite the large quantities of data on citizen-science platforms, these records have been mostly overlooked. In this publication, the first records of *S. caementarium* from six Eastern European and Balkan countries (Albania, Greece, Montenegro, Poland, Serbia, and Slovakia) are presented. Data derived from online citizen-science observations and museum specimens supplement our knowledge of this species' range. The distribution of this species in Europe and possible ecological implications are discussed.

Keywords

Alien species, biological invasions, citizen science, first record, mud daubers, Western Palearctic

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Introduction

Public participation in scientific research, also known as "citizen-science" has been found to yield valuable information on species distribution and phenology, population abundance, habitat structure, ecosystem productivity, and disturbance regime (Chadler et al. 2017). The latter is closely associated with alien and invasive alien species (IAS), which have been deemed as one of the main biodiversity threats addressed in the Convention on Biological Diversity 93/626/EEC. EU Regulation 1143/2014 indicates the necessity for early detection and rapid eradication of IAS, as well as the need for establishment of surveillance systems to mitigate negative impacts on biodiversity. Citizen-science data have facilitated numerous times these endeavors, offering an early insight into alien species' presence, distribution, and abundance, thus providing a powerful tool for biological invasion science (Maistrello et al. 2016; Pocock et al. 2017; Giovos et al. 2019; Johnson et al. 2020). Nevertheless, despite their valuable contribution in biodiversity research, data collected by citizen scientists rarely make their way into peer-reviewed scientific publications (Theobald et al. 2015; Johnson et al. 2020). The impact and potential of public participation in research seems in most cases to be undermined by professional science, negatively affecting both sides, instead of being embraced and integrated into scientific research (Theobald et al. 2015). Although taxonomic accuracy of photographic observations provided by citizen scientists is considered sometimes problematic (Stafford et al. 2010), many alien species can be easily distinguished from native counterparts due to their distinctive morphological features or taxonomic uniqueness (e.g. Davranoglou and Koutsoukos 2018; Kalaentzis et al. 2019; Kazilas et al. 2020).

In Europe, various alien Sphecidae have been introduced, have established populations, and are currently expanding their range, such as the Grass-carrying Wasp *Isodontia mexicana* (Saussure, 1867) (Polidori et al. 2018; Turrisi 2020) and several mud daubers belonging to the genera *Sceliphron* Klug, 1801 and *Chalybion* Dahlbom, 1843 (Schmid-Egger 2005; Rasplus et al. 2010; Baghirov 2011; Ćetković et al. 2011; Mei et al. 2012; Mei and Boščík 2016; Mokrousov et al. 2019; Demetriou et al. 2021). The genus *Sceliphron* is represented by 35 species widespread across all temperate and tropical areas of the world (Bohart and Menke 1976; Pulawski 2020). The Western Palearctic *Sceliphron* fauna consists of eight species, three of which are alien to the continent, namely: the Oriental *S. curvatum* (Smith, 1870) and *S. deforme* (Smith, 1856), as well as *S. caementarium*, which is native to the Nearctic zoogeographical realm (Ćetković et al. 2004; Schmid-Egger 2005; Ćetković et al. 2011).

The global distribution and human-mediated spread of *S. caementarium* has been remarkable (van der Vecht and van Breugel 1968). By the 1960s the species was collected from various localities of southern USA and South America (van der Vecht and van Breugel 1968). *Sceliphron caementarium* even managed to reach Pacific Islands such as Wallis Island, Samoa, Society Islands, Marquesas Islands, Gambier, Cook Islands, and New Caledonia, as well as Japan in the Eastern Palearctic realm (Krauss 1961; van der Vecht and van Breugel 1968). Since then, even more records have been detected in Japan (Nambu 1975; Takahashi and Shimizu 2001; Terayama 2004) as well as other Asian countries such as Bangladesh (Begum and Bose 1976), China (Hua 2006), Iran (Fallahzadeh et al. 2005, 2009), South Korea (Kim et al. 2014), and India (Gurule et al. 2020). In addition, records of individuals setting foot in Australia and intercepted in New Zealand have been reported (Naumann 1983; Early and Townsend 1993; Harris 1997).

The presumably oldest *S. caementarium* specimen collected in Europe dates back to 1825 from Madeira (van der Vecht and van Breugel 1968) followed by one in 1942 from Bohemia (Bogusch and Macek 2005). However, according to Vepřek and Straka (2007), the latter was considered controversial and the occurrence had never been confirmed, until its re-collection from the Czech Republic in 2012 (Popelka 2015). To this day, the species has been detected in Austria (Gusenleitner 2002), Belgium (Ravoet et al. 2017), Bosnia and Herzegovina (Ravoet et al. 2017), Bulgaria (Gradinarov 2017), Croatia (Gusenleitner 1996), France (Leclercq 1975) (including Corsica; Bitsch et al. 1997), Germany (Burger 2015), Hungary (Vas and Józan 2014), Italy (Pagliano 1992) (including Sicily; Turrisi and Altadonna 2017 and Sardinia; Cillo and Bazzato 2013), Luxembourg (Schneider and Pelles 1988), Malta (Cassar and Mifsud 2020), the Netherlands (Schmitz 2015), Portugal (Leclercq 1975) (including Madeira; Berland 1946; van der Vecht and van Breugel 1968), Romania (Gagiu 2012), Russia (Danilov 2017), Slovenia (Gogala 2011), Spain (Schmid-Egger 2005) (including the Balearic and Canary Islands; Erlandsson 1977; Díaz-Calafat 2020), Switzerland (Schmid-Egger 2005), and Ukraine (Antropov 1993).

This publication provides the first observational citizen-science records of *S. caementarium* in several European countries, updating the current distribution of this species in Europe.

Methods

Photographic material and data were examined from the iNaturalist online citizen-science platform (iNaturalist 2021), Observation.org (2021), and other online sources (Dr. M. Friedrich, pers. comm.). Individuals were identified based on the identification keys and species diagnoses of Schmid-Egger (2005), Vas and Józan (2014), and Díaz-Calafat (2020). Only reliable records were taken into account, thus excluding those observations where the angle of the pictures made impossible to observe diagnostic features. When presenting the Greek locality data, information is also given in brackets using the transliteration rules as per Salata et al. (2019). Observational data

concerning Greece were complemented with specimens deposited in the Museum of Zoology of the University of Athens, Greece (ZMUA; Fig.1). Regarding the species spread in Europe, Turrisi and Altadonna (2017) had already included Slovakia within the species' known distribution. However, this remark was deemed erroneous and not supported by the provided literature (G.F. Turrisi pers. comm.). Although Macek et al. (2010), briefly mentioned finding *S. caementarium* twice from Southern Slovakia in 2008, no further locality data, coordinates, dates, additional metadata, or other information about its establishment and habitat are provided. Thus, the first confirmed georeferenced records, alongside unquestionable photographic material as evidence of the presence of this exotic wasp in Slovakia, are hereafter added to the known distribution of *S. caementarium*.

Results

This research brings attention to several citizen-science observations, so far apparently overlooked, that represent the first record of *S. caementarium* in six European countries (Albania, Greece, Montenegro, Poland, Serbia, and Slovakia), including three Greek islands (Corfu, Ithaki, and Patmos). These new data supplemented by our personal contributions increase our knowledge on the current distribution of *S. caementarium* in Europe (Fig. 2).

After reviewing several citizen-science platforms and authors' contributions, we found a total of 27 new records from six European countries. Part of these records can be accessed through GBIF (occurrence download https://doi.org/10.15468/dl.ah2w5n).

New records. ALBANIA – **Qarku i Durrësit** • Durrës, Rruga e Yjeve; 41.3161°N, 019.4926°E; 30.VIII.2019; A. Ndoni obs.; iNaturalist (https://www.inaturalist.org/observations/31778923) – **Qarku Vlorë** • Vlorë; 40.4864°N, 019.4771°E; 26.VI.2020; A. Golemaj obs.; 1 ♂; iNaturalist (https://www.inaturalist.org/observations/47413401).

GREECE – **Attica [Attiki]** • Athens [Athina], Kryoneri; 38.1450°N, 023.8340°E; 3.VIII.2016; Dr. Christos Georgiadis leg.; 1 ♀; deposited at the ZMUA (voucher code: ZMUA HYM 00000011) • Nea Peramos; 38.0012°N, 023.4198°E; 8.VIII.2021; E. Koutsoukos leg.; 1 ♀; deposited at the ZMUA (voucher code: ZMUA HYM 00000241) – **Ionian Islands** • Corfu [Kerkyra], Dassia; 39.68°N, 019.84°E; 8.IX.2011; Dr. M. Friedrich obs.; (https://arthropodafotos.de/dbsp.php?lang=eng&sc=0&ta=t_43_hym_apo_sph&sci=Sceliphron&scisp=caementarium) • Ithaki, Vathí [Vathi]; 38.3608°N, 020.7162°E; 30.VII.2018; J. Mees obs.;

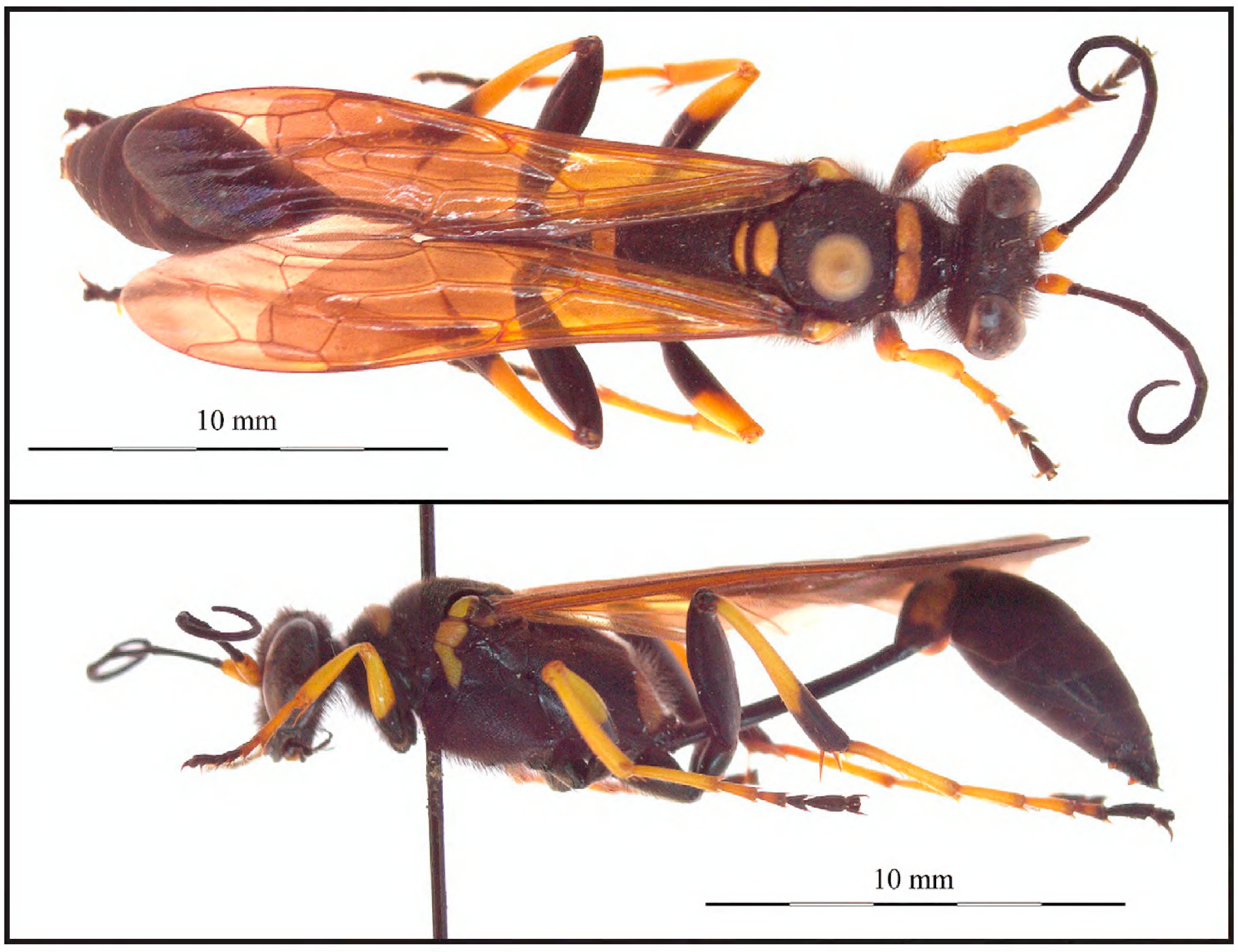

Figure 1. *Sceliphron caementarium* (Drury, 1773), ♀ specimen deposited at the ZMUA. **A.** Dorsal view. **B.** Lateral view. Scale bar = 10 mm. Note the completely black hind femora, yellow scapus and collar.

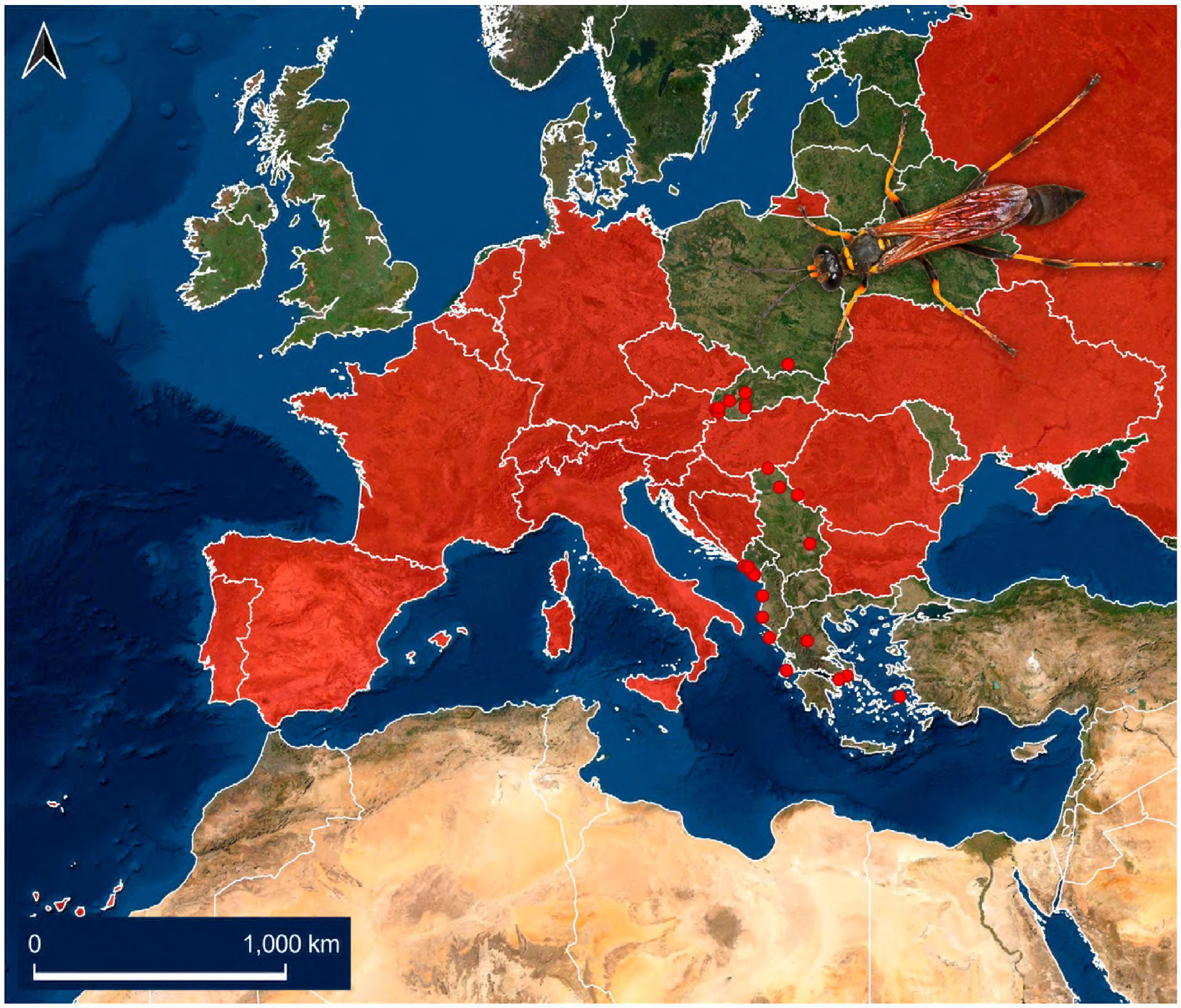

Figure 2. Current known distribution of the alien *Sceliphron caementarium* (Drury, 1773) in the study area. Countries where the species has been previously reported are shaded red, while new records are depicted with dots. The map was created with QGIS, v. 3.14.16. Inset: *S. caementarium* (photo by Judy Gallagher).

Observation.org (https://observation.org/observation/161214565/) – **South Aegean** • Dodecanese [Dodekanisa], Patmos; 37.3007°N, 026.5545°E; 3.VI.2021; C. Spoorenberg obs.; 1 ♂; Observation.org (https://observation.org/observation/215939100/) – **Thessaly** • Trikala, Agios Georgios park; 39.5446°N, 021.7866°E; 13.VII.2019; N. Papageorgiou obs.; 1 ♀; iNaturalist (https://www.inaturalist.org/observations/28725388).

MONTENEGRO – **Opština Budva** • Bečići; 42.2837 °N, 018.8796°E; 11.VII.2019; E. Meyke obs.; iNaturalist (https://www.inaturalist.org/observations/28603679) – **Opština Bar** • Brca; 42.1327°N, 019.0674°E; 19. VI.2021; П. Несмеянов obs.; iNaturalist (https://www.inaturalist.org/observations/83616345) – **Opština Herceg Novi** • Herceg Novi; 42.4573°N, 018.5315°E; 17.IX.2020; D. Lupin obs.; iNaturalist (https://www.inaturalist.org/observations/62249184) • Bijela; 42.4535°N, 018.6498°E; 22.VII.2021; F. Ribeiro obs.; 1 ♀; iNaturalist (https://www.inaturalist.org/observations/89702238) – **Opština Kotor** • Kotor; 42.4254°N, 018.7704°E; 9.VII.2021; O. Malikin obs.; 1 ♀; iNaturalist (https://www.inaturalist.org/observations/86279111).

POLAND – **Małopolskie** • Gorlice; 49.660°N, 020.800°E; VIII.2021; username: rece69 obs.; iNaturalist (https://www.inaturalist.org/observations/91391207).

SERBIA – **Južnobanatski okrug** • Južno-Banatski, Vršac; 45.111187°N, 021.295293°E; 11.IX.2020; B. Radeka obs.; 2 ♀♀; iNaturalist (https://www.inaturalist.org/observations/59576412) – **Nišavski okrug** • Nišavski, Niš; 43.3080°N, 021.9227°E; 5.VI.2018; S. Stevčić obs.; iNaturalist (https://www.inaturalist.org/observations/26109651) – **Severnobački okrug** • Severno-Bački, Subotica; 46.0684°N, 019.7661°E; 4.VIII.2019; M. Bárta obs.; 1 ♀; iNaturalist (https://www.inaturalist.org/observations/30384199) – **Srednjobanatski okrug** • Srednje-Banatski, Zrenjanin; 45.3800°N, 020.3603°E; 2.VIII.2021; I. Pancic obs.; 1 ♀; iNaturalist (https://www.inaturalist.org/observations/89621771).

SLOVAKIA – **Bratislavský kraj** • Bratislava; 48.1458°N, 017.0733°E; 31.VII.2021; F. Bednar obs.; 1 ♂; iNaturalist (https://www.inaturalist.org/observations/89706820) • Bratislava, Rusovce; 48.0532°N,

017.1501°E; 22.VIII.2020; M. Beděra obs.; iNaturalist (https://www.inaturalist.org/observations/57216019) • Bratislava, Senec; 48.0341°N, 017.2272°E; 6.IX.2020; username: oblong obs.; 1 ♀; iNaturalist (https://www.inaturalist.org/observations/58728425) • Bratislava, Senec; 48.183972°N, 17.247784°E; 28.IX.2021; V. Hemala obs.; iNaturalist (https://www.inaturalist.org/observations/96556833) – **Nitriansky kraj** • Nitriansky, Levice, Levické lake; 48.2861°N, 018.6172°E; 2.VII.2020; P. Hoffmann obs.; 1 ♀; iNaturalist (https://www.inaturalist.org/observations/28602171) • Nitriansky, Levice; 48.1888°N, 018.6145°E; 25.VIII.2019; P. Hoffmann obs.; 2 ♀; iNaturalist (https://www.inaturalist.org/observations/31540931) – **Trenčiansky kraj** • Prievidza, Lehota pod Vtáčnikom; 48.6986°N, 018.6086°E; 29.VIII.2020; F. Vida obs.; 1 ♂; iNaturalist (https://www.inaturalist.org/observations/57915716) – **Trnavský kraj** • Trnavský, Hlohovec; 48.4267°N, 017.7977°E; 21.VIII.2021; E. Uhrakova obs.; 1 ♀; iNaturalist (https://www.inaturalist.org/observations/92018292).

Identification. The species can be distinguished by its yellow scapus, black mesosoma with yellow collar, tegula, scutellum, and postscutellum, and two yellow spots on the mesopleuron. These yellow markings can be more-or-less obvious depending on the specimen's population and its provenance. The propodeum is yellow and the first metasomal tergite usually bears a yellow spot. Hind femora are completely black, as opposed to other *Sceliphron* species found in Europe. The petiole is usually black, or quite less frequently yellow or bicolored yellow/black (Schmid-Egger 2005; Vas and Józan 2014; Díaz-Calafat 2020).

Discussion

In most of cases, *S. caementarium* seems to have established viable populations in its newly recorded invaded countries. This is evidenced by both individuals being recorded at least during the last two years but also by the presence of females either collecting nesting material or building a nest itself, meaning a successful copulation and implicating breeding that could secure a viable population. In addition, it is of significant interest that the first photographic record of *S. caementarium* from Greece was taken in 2011 (Corfu), while the lone specimen from the ZMUA was collected in 2016 (Athens). The remaining citizen-science observations from Greece unveil an extended distribution in the country, with potentially alarming impacts towards native biodiversity in fragile island ecosystems (Reaser et al. 2017). Such an example reinforces the positive impact of citizen-science data in mapping alien species' distribution, setting the approximate timeframe of initial invasion and assessing their status. Regarding Poland, more research is due in order to clarify the presence of established populations as just one citizen science observation was detected. The present study deems the Nearctic *S. caementarium* widely distributed in the Western Palearctic, currently present in 26 countries (Fig. 2). Taking into account the extensive distribution of the species in Eastern Europe and the Balkans, the species is predicted to be found in neighboring countries such as North Macedonia, Moldova, and Turkey. Nevertheless, based on the repeated history of unsuccessful introductions of this species in Europe (Leclercq 1975; Bogusch and Macek 2005), it is difficult to assess the invasion history of such wasp in the Old World without taking a molecular approach.

Most observations were made in urban and semi-urban areas and involved the nesting activities of *S. caementarium*, which have been associated with human settlements (Bohart and Menke 1976). As in the case of *S. curvatum*, urban areas may be facilitating the spread of *S. caementarium* into higher latitudes (Polidori et al. 2021). Therefore, further research could shed a light into the potential distribution of the species based on its ecological and climatic requirements, taking into account how climate change may affect its dispersal and possibility of establishment. Furthermore, taking into account the sporadic reports of the species in countries such as the Czech Republic (Bogusch and Macek 2005; Popelka 2015) where populations may have gone extinct and recently accidentally re-introduced, countries numbering only a handful of records (e.g. Albania and Poland) and countries with multiple records such as Italy (Pagliano 1992, 1995, 2009; Strumia 1996; Grillenzoni and Pesarini 1998; Pagliano et al. 2000; Hellrigl 2004, 2006, 2012; Schmid-Egger 2011; Ceccolini and Paggetti 2011, 2012; Cillo and Bazzato 2013; Dollfuss 2016; Turrisi and Altadonna 2017), a molecular approach could help assess the invasiveness and management of this species in Europe. A genomic analysis such as that of Kotsakiozi et al. (2017) on *Aedes albopictus* (Skuse, 1894) could unveil the number of different introductions in the Western Palearctic, the species' pathways of spread, origin, genetic structure, and differentiation of populations. Thus, such a genomic analysis would assist monitoring efforts by predicting invasion patterns and establishment based on climate matching between source and invasive localities (Kotsakiozi et al. 2017).

Various researchers have commented on the potential ecological threats of alien *Sceliphron* spp., with Ćetković et al. (2011) stating them as "potentially invasive". The existing knowledge concerning the invasiveness of alien *Sceliphron* spp. is summarized by Turrisi and Altadonna (2017) and Díaz-Calafat (2020). The alien species has been shown to gradually replace native *Sceliphron* species; e.g. *S. spirifex* in southern France (Piek 1986; Hamon et al. 1994) and *S. destillatorium* in Italy (Campadelli et al. 1999). According to Díaz-Calafat (2020), *S. caementarium*, *S. curvatum*, and *S. spirifex* were observed collecting nesting material without showing strong signs of interspecific competition. The same conclusions were drawn by Bitsch (2010), while observing coexisting *S. caementarium*, *S. curvatum*, and *S. destillatorium* populations. Furthermore, *S. caementarium* has

been found to prey upon native European spiders of the families Araneidae and Oxyopidae (Gros 2020). Some of these species are also known prey of *S. destillatorium*, such as *Argiope lobata* (Pallas, 1772) and *Neoscona adianta* (Walckenaer, 1802) (Fateryga and Kovblyuk 2014). On the other hand, although no trophic niche partitioning was found between *S. caementarium* and native *S. spirifex* in Italy (Polidori et al. 2007), foraging and resource use of *S. caementarium* has been shown to vary, with both specialists and generalists coexisting within a population (Powell and Taylor 2017). A more recent study in Italy, classified the species as having minor impacts on native biodiversity (Molfini et al. 2020). This conclusion was derived from a single article on the presence of *S. caementarium* in Liguria (Pagliano 1995) despite of more than a dozen of articles addressing its ecology, distribution, and impacts (Pagliano 1992, 2009; Strumia 1996; Grillenzoni and Pesarini 1998; Pagliano et al. 2000; Hellrigl 2004, 2006, 2012; Schmid-Egger 2011; Ceccolini and Paggetti 2011, 2012; Cillo and Bazzato 2013; Dollfuss 2016; Turrisi and Altadonna 2017). Thus, a detailed, quantitative study of trophic resources and nesting sites across the invaded range of *S. caementarium* would be highly encouraged, in order to carefully evaluate the possible ecological niche overlapping with native species and carefully assess its invasiveness over the time (Díaz-Calafat 2020). Thus, even though more research is needed regarding the trophic preferences, nesting ecology and species interrelationships of *S. caementarium* in Europe [currently restricted to Campadelli et al. (1999) and Gross (2020)], it seems that the ecological impacts of *S. caementarium*, as well as other alien *Sceliphron* spp. on native biodiversity have not been adequately explored yet.

In conclusion, the alien *S. caementarium* has managed to spread throughout the vast majority of Europe without receiving adequate attention regarding its presence, population abundances, and invasiveness. This is evidenced both by the minimal contributions regarding national or European data surrounding its nesting ecology and species interrelationships as well as the sheer volume of overlooked available data found in citizen-science platforms (e.g. iNaturalist, Observation.org). As highlighted by this study, citizen scientists can be a valuable source of information regarding the detection and spread of alien species. Moving forward, public participation in scientific research could be harnessed towards unravelling the invasiveness and ecological interactions of *S. caementarium* with native biodiversity. Countries such as Greece, Montenegro, and Russia, where all three alien *Sceliphron* spp. have been reported, should be of special interest, as to the possible ecological impacts lurking (Ćetković et al. 2011).

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Authors' Contributions

Conceptualization: EK, JD. Data curation: JD, CK, KK. Formal analysis: KK, JD, CK. Funding acquisition: JD. Investigation: CG, GFT, JD, KK, CK, EK, JDC. Methodology: JD, EK. Project administration: JD, EK. Resources: CG. Supervision: EK. Validation: JD, GFT, CG, JDC. Visualization: KK, JD, CK. Writing – original draft: CK, KK, JD, JDC, EK. Writing – review and editing: CG, JD, EK, KK, JDC, GFT, CK.

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